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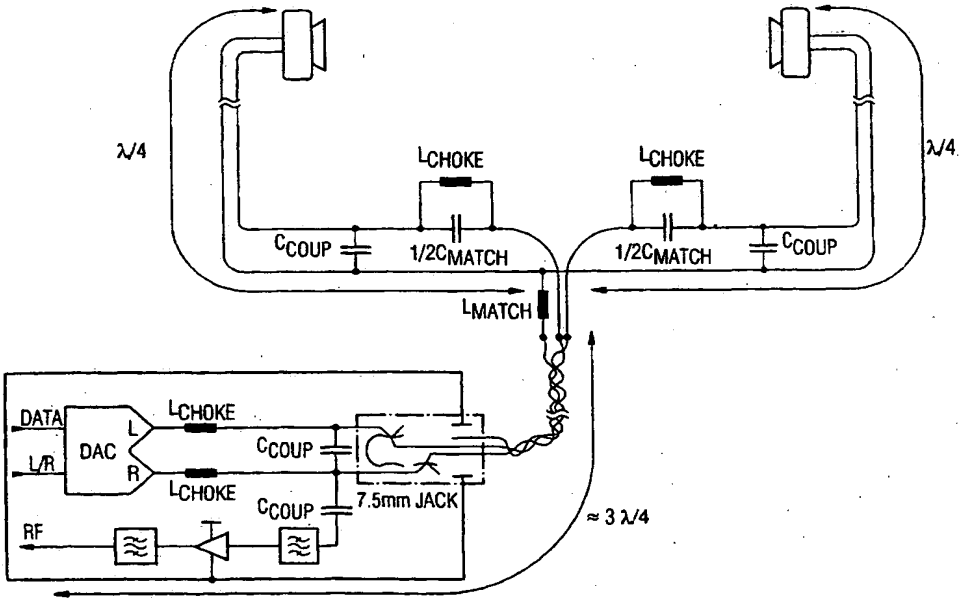
[Continued on next page]

(54) Title: A HEADPHONE



(57) Abstract: A receiver assembly comprising a housing, receiver unit, and having left and right audio stereo output lines which connect to a connection for connection to a headphone each of left and right lines having a impedance in series and also having a capacitance connecting the left and right audio lines said capacitance being located at a point between the connector and non output side of the inductance and wherein the receiver unit and audio lines are connected via an inductance.

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A HEADPHONE

The invention relates to a headphone having a lead that functions not only to supply audio signals to the headphone earpieces, but also as an antenna for receiving radio frequency (RF) signals for a receiver.

The use of a headphone lead as an antenna is not new. Previously this has taken the simplest form for FM broadcast receivers in which the headphone simply functions as a length of wire attached to an RF input receiver. A disadvantage of such an arrangement is that it is inefficient, since the relatively long length of wire (compared with the dimensions of the receiver housing) makes for an inefficient antenna dipole.

It is an object of the invention to overcome the above problems.

According to a first aspect of the present invention there is provided a headphone having at least two wires, at least one of which is an audio wire, said at least one audio wire being connected to a jack for input into a receiver/audio unit, and said wires also being connected to a common ground line, said ground line extends from the jack such that it is connected to the casing of said receiver audio unit when the jack is connected thereto so as to extend the length of the audio wire.

In a portable FM broadcast receiver, the signal field strength is so high, and the anticipated performance minimal enough, that the antenna efficiency is not critical.

However the headphone arrangement of the antenna typically comprises two ear phones each having similar configuration of audio wires, so as to provide stereo sound. In such a case a preferred embodiment comprises two headphones each connected to at least two wires, at least one of which is an audio wire; each of said audio wires being connected to a jack for input into a receiver/audio unit and at least another of said wires is connected to a common transmission ground line, said ground line extending from the jack such when connected to an audio unit the length of the audio wire is extended.

Such a headphone arrangement is adapted to be plugged into an adapter unit, which comprises a socket for a jack connector for connection to a receiver/audio unit, and connected to said jack connector and extending therefrom first and second feeds each comprising a wire connected to left and right headphones respectively, and including a transmission line/screen lead/ground feed extending, from the connector at a proximal end, partially along the length of the left and right feed from said connector, and for each headphone, an earth connection wire extending partially along the length of the audio feeds to a common point connection, said common point connection being connected to the distal end of said ground feed via an impedance

and wherein each of said earth connections is connected to the respective audio line via a capacitance.

The transmission line is preferably a co-axial cable or it may form, along with the other wires, a twisted three core lead.

The invention will now be described with reference to background principles and examples, and with reference to the following figures of which:

Figure 1 illustrates the background principles of the invention;

Figure 2 shows schematic and practical embodiments of the invention;

Figure 3 shows a preferred embodiment of the invention showing a refinement of the figure 2 embodiment;

Figure 4 shows an alternative embodiment of the invention; and

Figure 5 illustrates the practical dimensions of leads according to preferred embodiments of the invention.

Figure 1a shows a simple representation of a simple dipole antenna 1 housed in a housing 2 of a receiver transmitter 3 and with radiation resistance R_{ant}. The antenna 1 is fed directly by a self contained (i.e. no power or ground connections) and electro-

magnetically fully screened RF source of matched impedance. In this example the antenna is referred to as a transmitter rather than operating in a receiving mode and this facilitates explanation.

If an RF source is considered to be sufficiently small then its housing 2 can be included in a lower part of the dipole as shown in Figure 1b. The inventor has determined that by extending this concept, the exact location of the RF source, within the lower half of the dipole, is immaterial. The RF source can be re-located to the bottom of the lower part of the dipole using a coaxial feed 4 (or other extension of the housing) up the centre of the lower part of the dipole with no change in electro-magnetic radiation behaviour of the antenna system as shown in Figure 1c. The effective electrical length of this coaxial feeder part of the system is immaterial to the antenna function.

Figure 2a shows an adaptation of a standard headphone system to an embodiment of the invention based on the principle of the invention. Figure 2a shows a receiver unit 5 having left 6 and right 7 audio output being fed via a socket 8 to a stereo headphone jack 9 connected to left and right headphones 10 and 11 respectively via a point where the lead divides from which audio/ground pairs continue to each ear piece. Each of the headphones also has a ground connection 12 which is connected to casing 13 of the receiver unit.

By breaking ground connection to each ear phone, and placing RF coupling capacitors 14 and 15 (having low impedance at RF, but high impedance at audio) across the audio/ground pair feeds to the ear

phones they are made into effectively consolidated RF pairs. The resulting lead arrangement is similar to the end fed dipole system of figure 1c with the exception that the upper half of the dipole consists of two branches rather than one as shown in Figure 2b and 2c. Figure 2c shows a simple representation of the circuit of Figure 2b.

Figure 2d shows an alternative embodiment of the invention. As before the arrangement comprises two ear phones each having a pair of audio leads 16 a,b and 17 a,b. One of each of the pair of audio leads 16a and 17a is connected to a jack which is shown in connection with the receiver unit 18. The jack connection in the socket 19 is such that the leads 16a and 17a are connected to left and right outputs from an audio unit 20, each via a further impedance 21, 22. This impedance is high at RF but low at audio frequencies. The leads are also connected to the receiver unit via capacitances 23 and 24. In this way the headphones act as an antenna for input into the receiver 25 of the receiver unit as well as the output from the audio unit.

Other leads to the headphones 16b and 17b, which may be regarded as ground leads are truncated and connected together to a common point "A". Leads 16a and 17a are also connected to this point via capacitors 26 and 27. Leads 16b and 17b are further connected, via inductor 28 (which is of high impedance at RF but low impedance at audio frequencies) to the end of a coaxial cable 29. The coaxial cable 29 is essentially a sheathing around the jack and is connected or earthed to receiver unit housing 30.

The impedance of a dipole is typically higher than the commonly used 50Ω RF interface to the receiver. An impedance transform, with a suitable two-element matching network, is preferred to achieve an enhanced performance. This is implemented schematically in Figures 3a and 3b. A practical implementation is shown in Figure 3c. The arrangement is similar to that of Figure 2c except, that it includes for each earpiece, a parallel arrangement of a capacitance 31, and impedance 32. Dotted line in the Figure 3c represents a matching circuit.

As far as the length of the wires (used as head set leads) is concerned it is possible to extend their length to form a practical headphone system for Digital Audio Broadcast (DAB) application. The DAB VHF band is from 175MHz to 239 MHz and is centred on 208MHz which has a wavelength of 36cm. Whilst this length is ideal for an individual ear-piece feeder (comprising a top half of a dipole), it is too short to be of practical use, as the lower portion of a headphone lead set includes the radio device itself. Pocket radio product headsets typically have an overall antenna length in excess of 1m.

An embodiment of the invention incorporates these practical requirements and uses an asymmetrical dipole, in which upper half is approximately $\lambda/4$ but the lower half is closer to around $3\lambda/4$. This is shown in Figure 4. The resulting load impedance change in this design step is simply absorbed in the choice of value of the matching

components. By use of such matching as is appropriate, a wide range of lead lengths can be accommodated.

As mentioned in the above embodiments a co-axial feeder is used as an effective extension of the casing. However the invention is not limited to the use of a co-axial cable as the transmission (feed) line. A further practical advantage of the invention is that it requires relatively low cost components. Although the end-fed dipole antenna classically uses a coaxial feeder, the principle of its operation does not rely on this. As long as the feeder behaves as a transmission line at the RF frequencies concerned, (which can be ascertained by measurement of the loss per unit length of the line), then the field within the feeder structure is "locally-contained" and the end-fed dipole principle applies. Thin, flexible twin core coaxial lead is expensive and alternatives may be used.

In a particularly preferred embodiment a twisted three-core lead is used. The inventor has determined by measurements of the transmission line properties of a commercially available headphone lead wire with twisted three core, that it gives a reasonably low loss per unit length. The cable has a characteristic impedance approximate to 50Ω. An embodiment employing this cable is shown in Figure 5. Transmission feed line comprises a three-core lead, using one of the cores as the RF "ground" and the other two to function collectively as carrier of the RF signal. The principle of using a three-core lead as RF feeder works equally well with signal and ground lines reversed but the particular orientation chosen is most appropriate for integrating

with additional functionality of a stereo audio connection. The other two are the leads connecting the headphone to the jack. Apart from this, remaining components are identical to those in Figure 3c. The effectiveness of this arrangement was compared with that of a matched dipole test antenna and a matched ideal coaxial-based end fed wire dipole. The headphone antenna system and matched ideal coaxial based end fed wire dipole gains were very close (within 1-2dB) and both had a gain of −10dB with respect to the test antenna in the centre of the band, dropping to −13dB the band edges.

The invention has been described by way of examples only and variation may be made to the embodiments without departing from the scope of the invention.

CLAIMS

1. A headphone comprising: an earphone connected to at least a pair of wires, at least one wire is an audio wire, said at least one audio wire being connected to a jack for input into a receiver/audio unit and contact with a casing thereof; at least one of said wires being connected to a common ground line, which ground line is also connected to the jack, so that when the jack is in contact with the casing of the receiver/audio unit, the length of the audio wire is extended.

2. A stereo headphone comprising: two earphones, each connected to at least a pair of wires, at least one of each pair of wires is an audio wire, each of said audio wires being connected to a jack for input into a receiver/audio unit and contact with a casing thereof; and at least one of each pair of said wires being connected to a common ground line, which ground line is also connected to the jack, so that when the jack is in contact with the casing of the receiver/audio unit, the length of the audio wire is extended.

3. A stereo headphone as claimed in claim 1or 2 wherein said ground wire includes a circuit which is of high impedance to audio signals and low impedance to RF signals.

4. A stereo headphone comprising a jack connector for connection to a receiver unit, connected to said jack connector, and extending

therefrom, a left and a right feed comprising audio lines connected to left and right earphones respectively, and including a transmission line/screen and ground feed extending from the connector partially along the length of the left and right audio lines from said connector, and for each earphone, an earth connection wire extending to a common point connection, said common point connection being connected to said ground feed, via an impedance, and wherein each of said earth connections is connected to the respective audio line via a capacitance.

5. A stereo headphone as claimed in claim 4 wherein said transmission line is a coaxial cable.

6. A stereo headphone as claimed in claim 4 wherein said transmission line and said audio wires are in the form of a twisted three core lead form the distal and proximal ends of the transmission line.

7. A stereo headphone as claimed in any of claims 4 to 6 wherein a further parallel arrangement of a capacitance and an impedance is arranged in each audio line, at a point between the connection to the first capacitance and the distal end of the transmission line.

8. A receiver unit comprising: a housing containing a receiver unit, and audio output and connector means for receiving a headphone connector jack, wherein the audio output and receiver unit have a common connection point, and filtering means wherein there is an

inductance between said audio output and said connection point and a capacitance between said receiver and said connection point.

9. A receiver unit as claimed in claim 8 wherein said connector has an earth connection such that when the connector jack is inserted therein, a connection is made from one of the lines of the jack to the receiver unit casing.

10. A receiver unit as claimed in claims 8 or 9 wherein the audio unit is a stereo unit having two (left and right) outputs each having a separate line connected to said connector via an inductor, and each of said output lines being isolated from said receiver unit by way of first and second capacitors.

FIG 1A

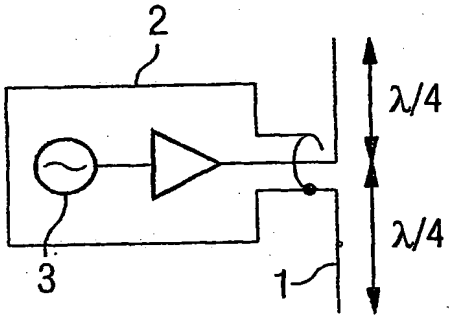


FIG 1B

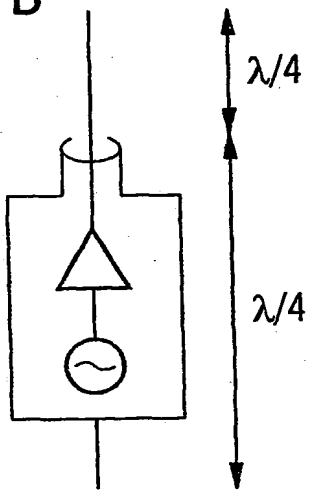


FIG 1C

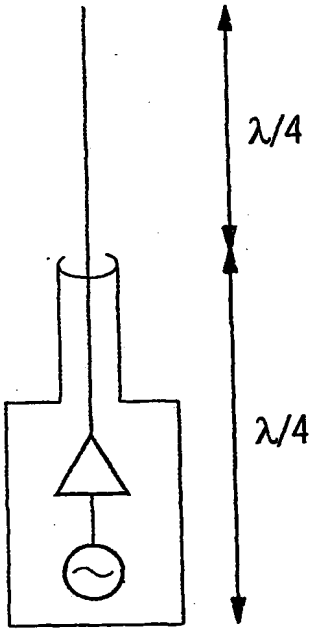


FIG 2A

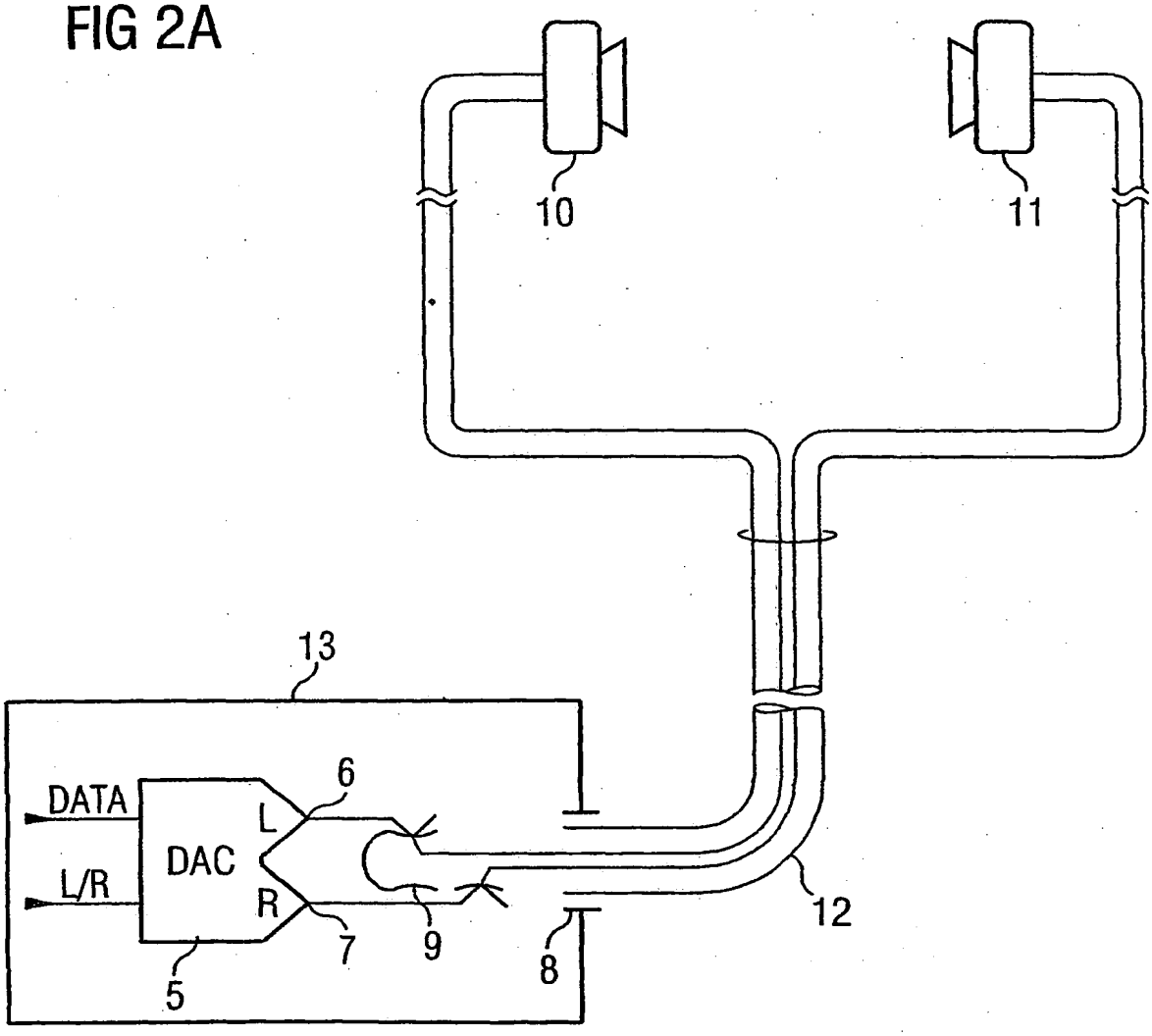


FIG 2C

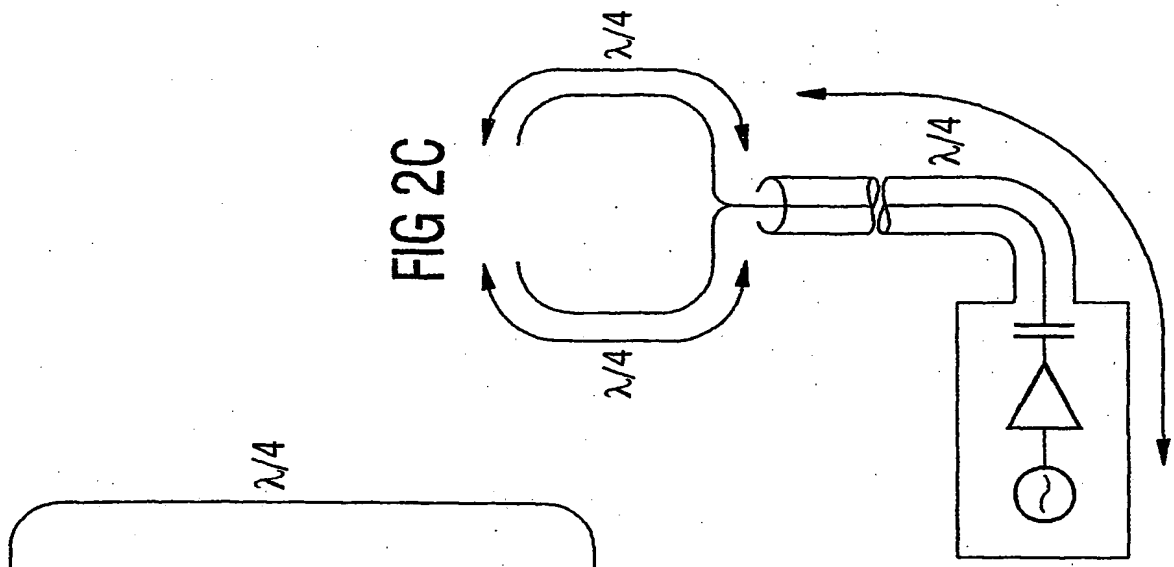
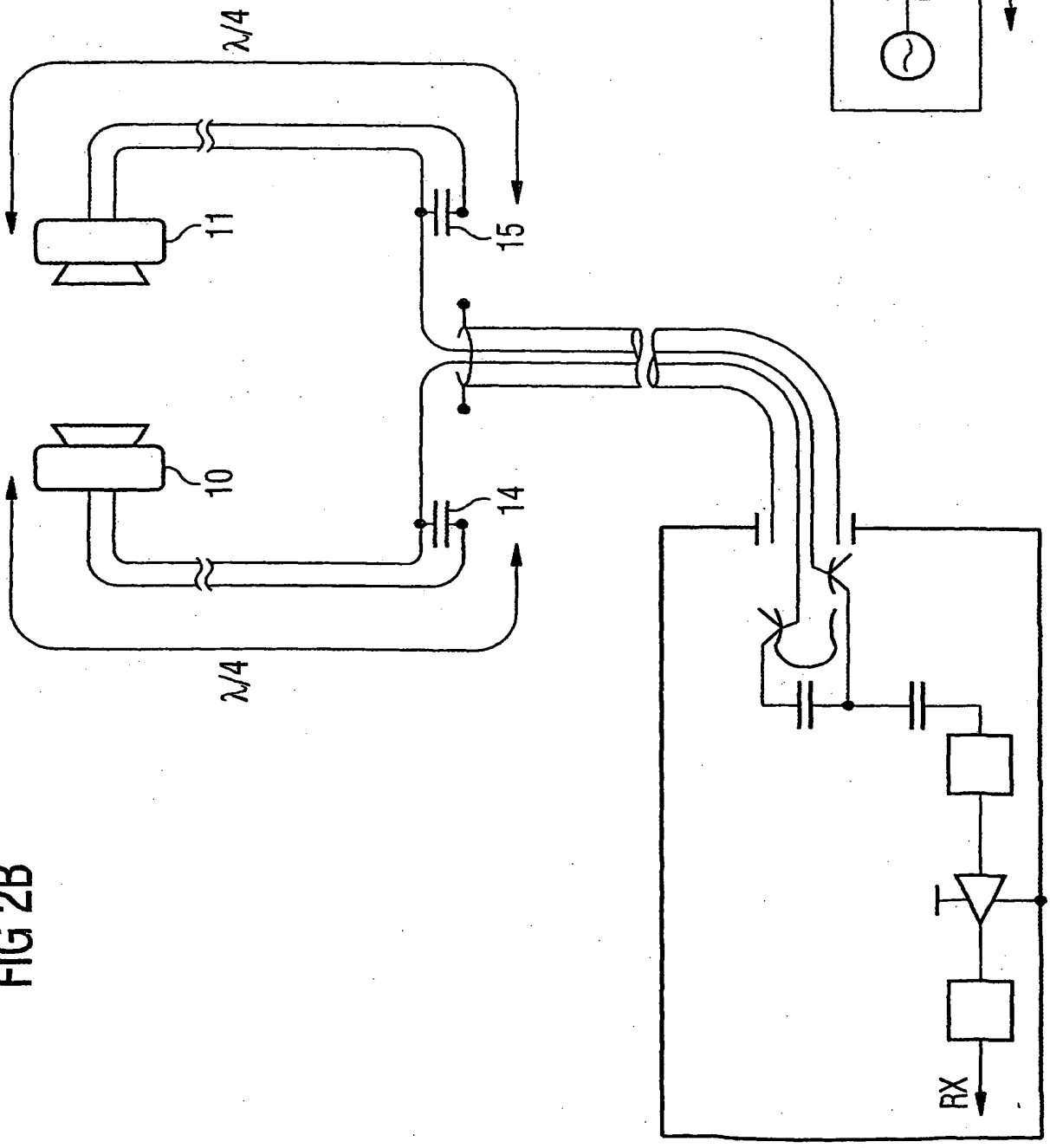


FIG 2B



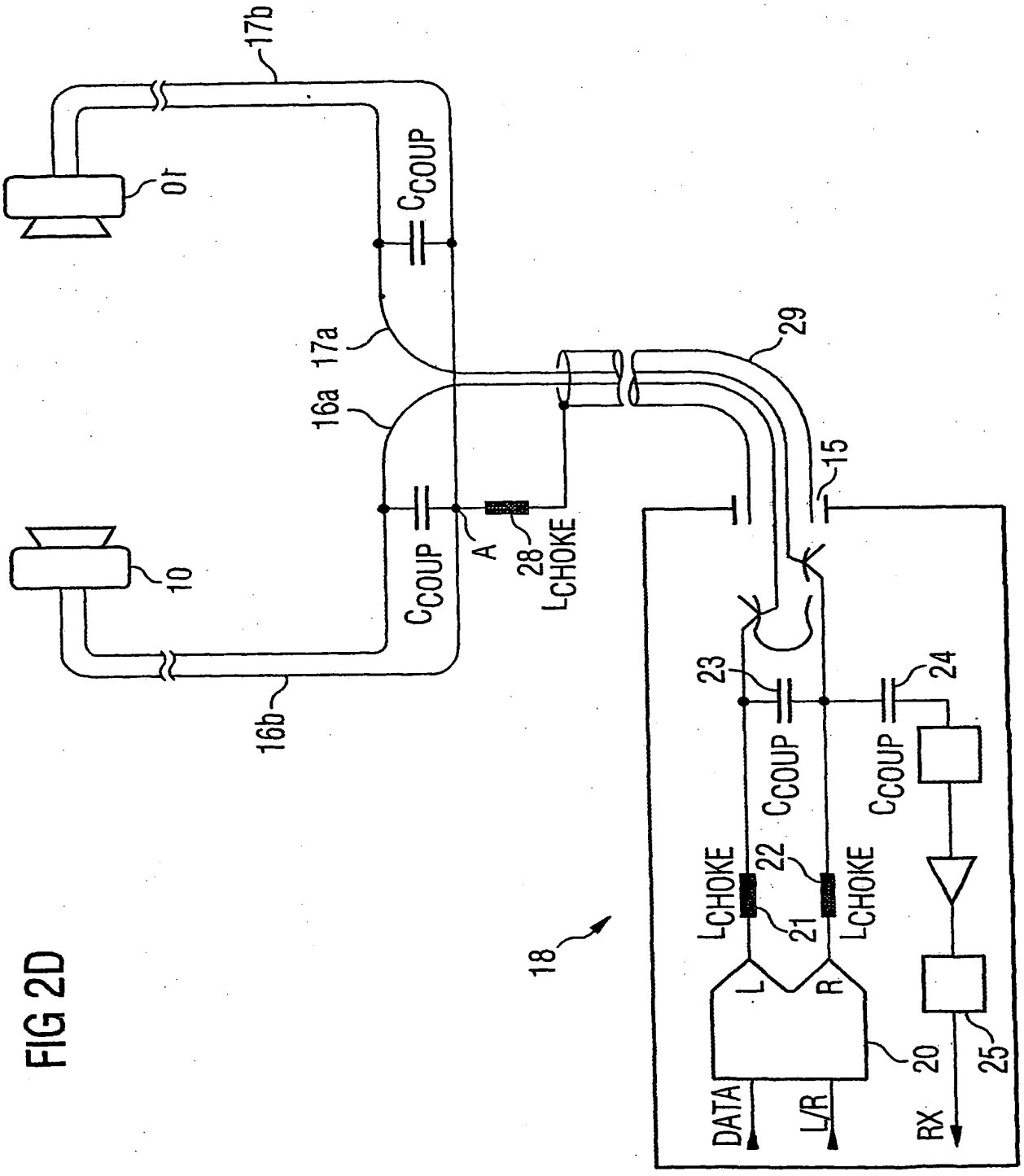


FIG 2D

FIG 3A

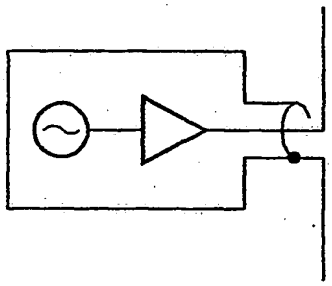
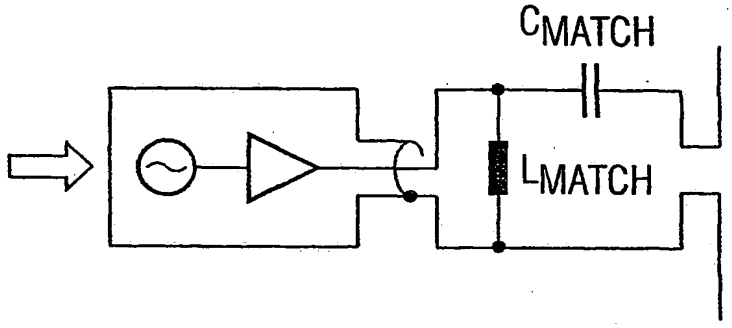


FIG 3B



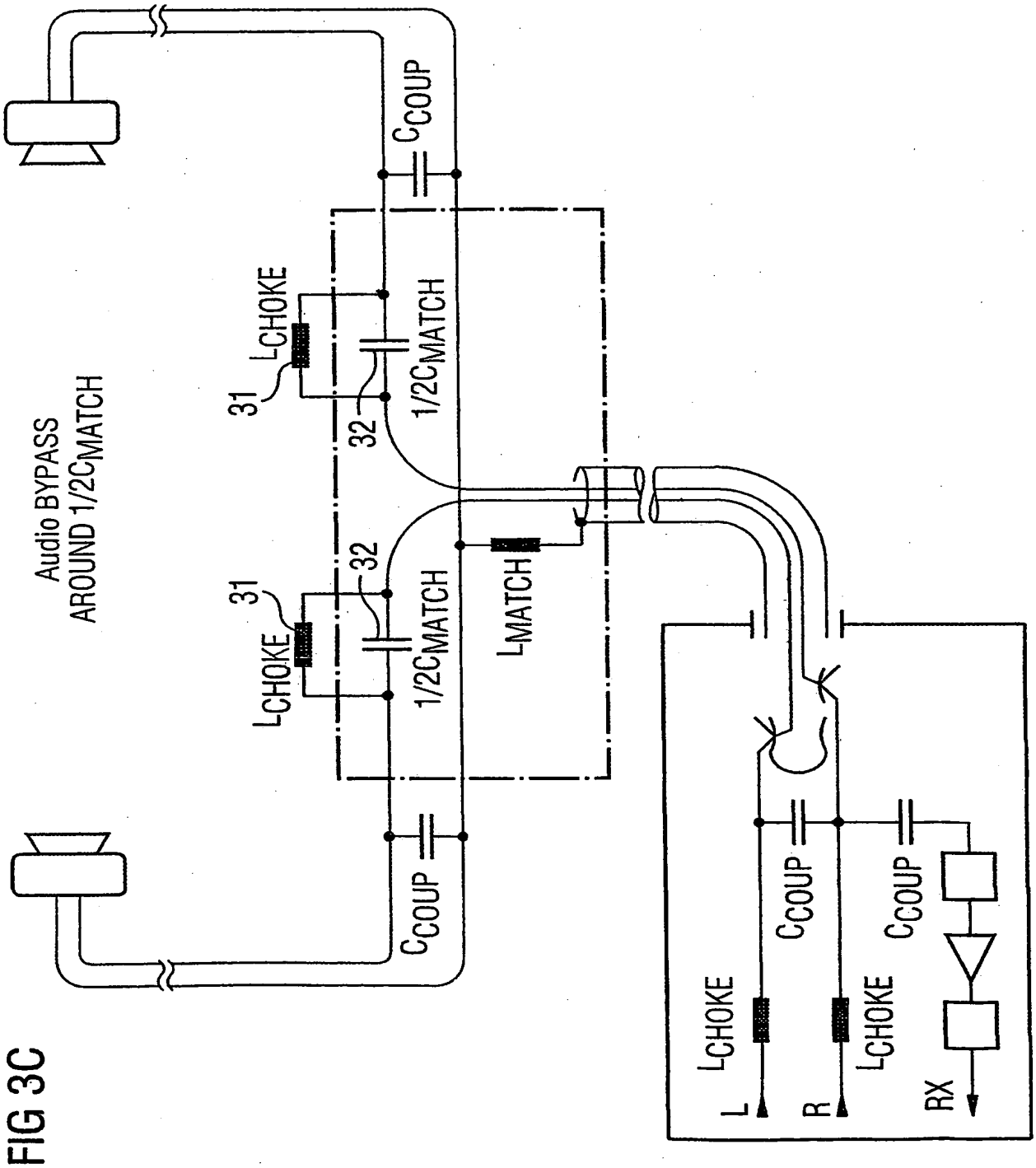


FIG 3C

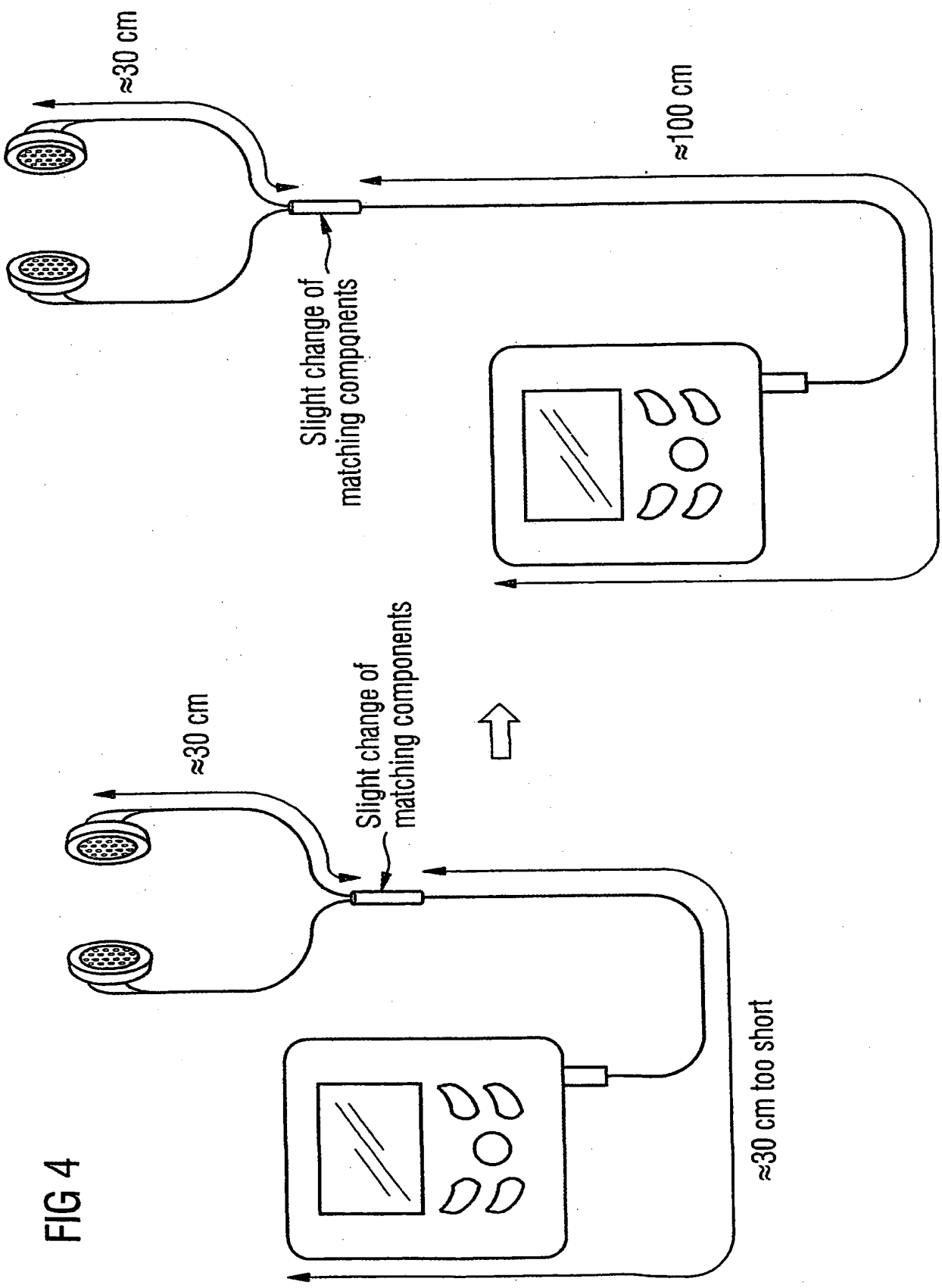


FIG 4

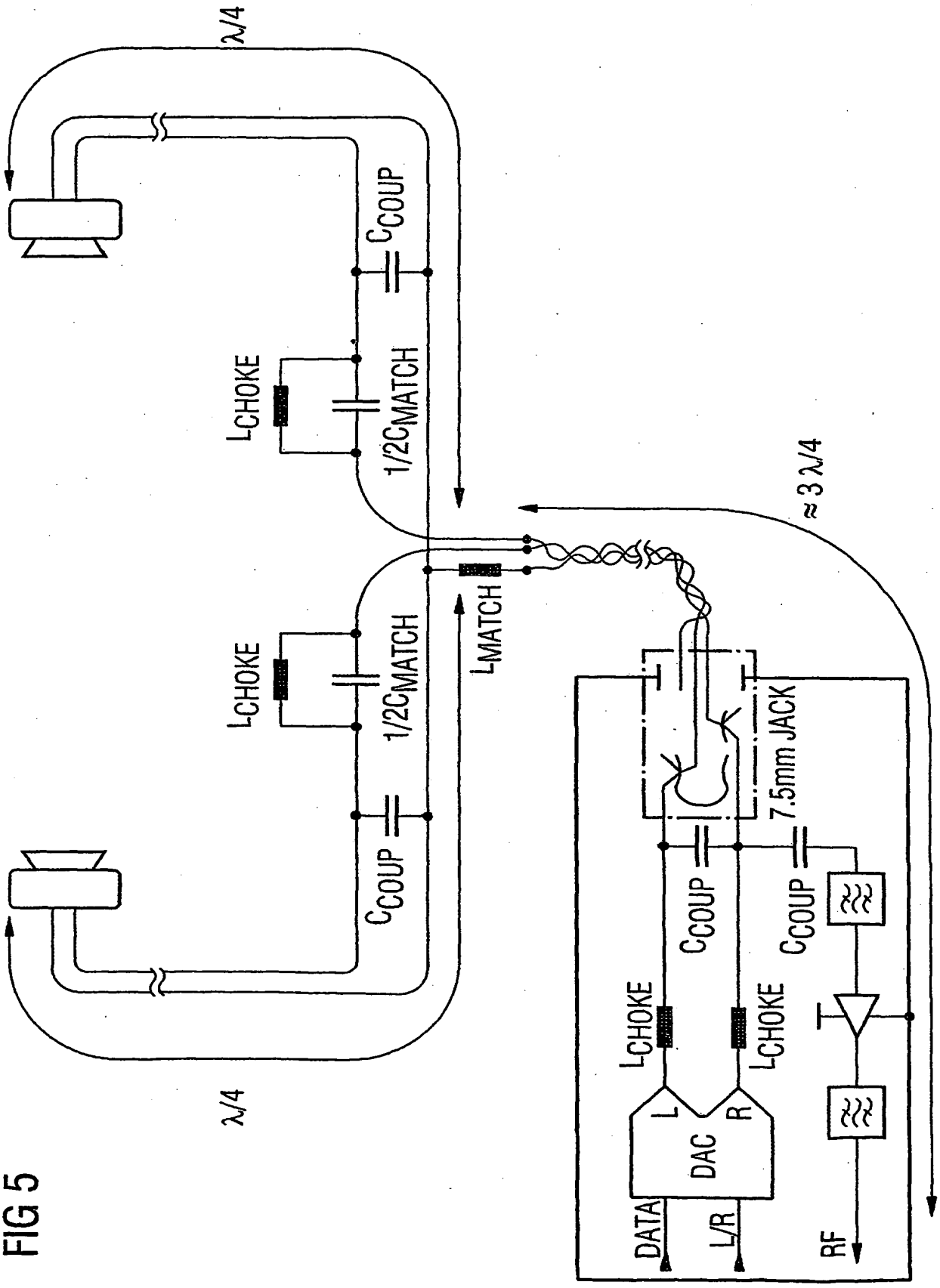


FIG 5

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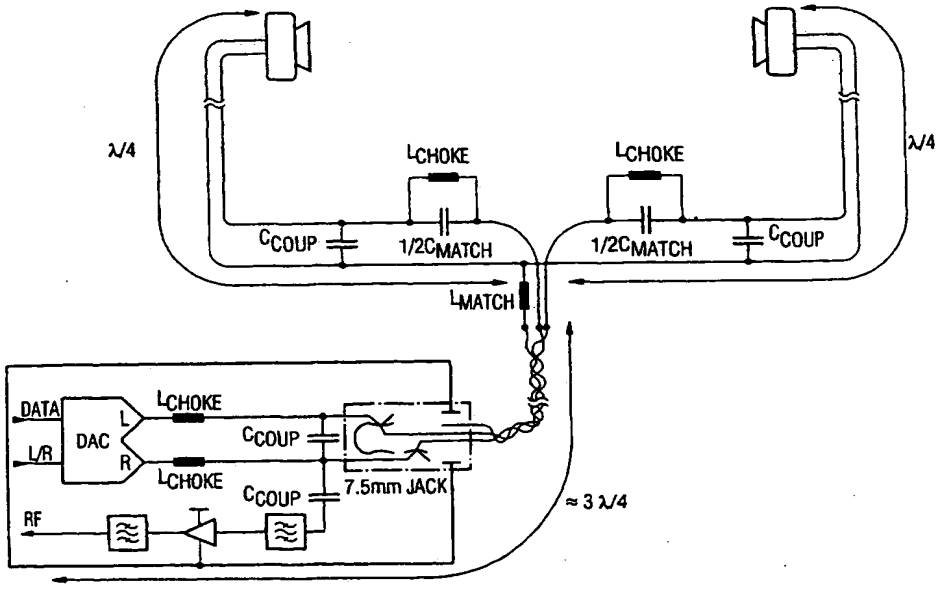

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 59 089004 A (MATSUSHITA DENKI SANGYO KK) 23 May 1984 (1984-05-23) abstract	1,2,8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
29 September 2003	07/10/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Tsapelis, A

Form PCT/ISA/210 (second sheet) (July 1992)

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Information on patent family members

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